

AMENDMENTS TO THE CLAIMS

1. (Currently Amended) A machine-implemented method of simulating, ~~in a machine,~~ a string, the method comprising:

simulating a force acting on the string by a stream of a fluid medium flowing in a direction that has a component along a longitudinal axis of the string;

~~using~~ forming a wave equation that relates movement of the string in time to the force acting on the string; and

generating a sound based on the movement described in the wave equation; ~~wherein the force acting on the string simulates a stream of a fluid medium flowing relative to the string.~~

2. (Original) A method according to claim 1, wherein:

the simulated string is supported between two supports and is aligned at rest in a first direction between the two supports;

a first of the two supports allows movement in a second direction orthogonal to the first direction and a second of the two supports does not allow movement; and

the string is caused from rest to vibrate in a plane, which includes the first and second directions, by turbulence in the fluid flow causing the stream of fluid medium to exert a pressure on the string in the second direction.

3. (Currently Amended) A method according to claim 2, wherein:

movement of the string out of alignment with the first direction causes the stream of fluid medium flowing in the first direction to exert ~~a~~ the force on the string in the second direction.

4. (Original) A method according to claim 1, wherein:

the simulated string is supported between two supports aligned in a first direction,

a first of the two supports is rigid and a second of the two supports allows movement in a second direction orthogonal to the first direction; and

the string is caused to vibrate in a plane, which includes the first and second directions, by the stream of fluid medium flowing in a direction having a component in the second direction.

5. (Original) A method according to claim 1, wherein:
the simulated string is supported between two supports aligned in an x-direction;
a first of the two supports allows movement in a y-direction orthogonal to the x-direction
and a second of the two supports does not allow movement;
the string comprises a plurality of discrete elements aligned at rest in the x-direction and
spaced apart by a distance dx; and
the discrete elements are able to move in discrete steps of time dt in the y-direction only.
6. (Original) A method according to claim 5, in which the string comprises a plurality of j
discrete elements from j=0 at one end movably supported by the first support to j=x-1 at the
opposite end immovably supported by the second support; wherein
j is an integer; and
the stream of fluid medium flows in the x-direction and exerts a pressure on the string
between elements j=0 and j=1.
7. (Original) A method according to claim 6, wherein the force $F_{PRES}[n, 0]$ at time n acting
on the immovably supported element j=0 due to the pressure on the string between the movably
supported element j=0 and adjacent element j=1 is given by:

$$F_{PRES}[n, 0] = P * (y[n, 0] - y[n, 1]) / dx$$

in which:

P denotes the pressure exerted by the stream of fluid medium on the string between the
movably supported element j=0 and adjacent element j=0;

y[n, 0] denotes the excursion of the movably supported element j=0 at time n; and

y[n, 1] denotes the excursion of the adjacent element j=1 at time n.

8. (Original) A method according to claim 6, wherein the force $F_{TURB}[n, 0]$ at time n acting
on the immovably supported element j=0 due to the turbulence in the stream of fluid medium is
given by:

$$F_{\text{TURB}}[n, 0] = C_{\text{TURB}} * N_{\text{RND}}[n]$$

in which:

C_{TURB} denotes a turbulence coefficient; and

$N_{\text{RND}}[n]$ denotes a random signal.

9. (Original) A method according to claim 8, wherein the random signal comprises a low pass filtered noise.

10. (Original) A method according to claim 6, wherein the excursion $y[n+1, 0]$ of the movably supported element for the next sample due to the pressure on the string between the movably supported element $j=0$ and adjacent element $j=1$ is given by:

$$y[n+1, 0] = y[n, 0] + (F_{\text{PRES}}[n, 0] + F_{\text{TURB}}[n, 0]) * dt^2 / M[0]$$

in which:

$y[n, 0]$ denotes the excursion of the movably supported element $j=0$ at time n ; and

$F_{\text{PRES}}[n, 0]$ denotes the force at time n acting on the movably supported element $j=0$ due to the pressure on the string between the movably supported element $j=0$ and adjacent element $j=1$;

$F_{\text{TURB}}[n, 0]$ denotes the force at time n acting on the movably supported element $j=0$ due to the turbulence in the stream of fluid medium; and

$M[0]$ denotes the mass of the movably supported element $j=0$.

11. (Original) A method according to claim 10, wherein the excursion $y[n+1, 0]$ is limited.

12. (Original) A method according to claim 6, wherein the stream of the fluid medium exerts a pressure on the string between each of the elements; and

wherein the force $F[n, j]$ at time n acting on each discrete element from $j=1$ to $j=x-2$ due to the pressure P is given by:

$$F[n, j] = P[j] * (y[n, j] - y[n, j-1]) / dx + P[j] * (y[n, j] - y[n, j+1]) / dx.$$

13. (Currently Amended) A method according to claim 12, wherein the pressure P decreases linearly or exponentially with increasing j.

14. (Original) A method according to claim 5, wherein the wave equation is an approximation of the continuous wave equation

$$M \frac{\partial^2 y}{\partial t^2} = T \frac{\partial^2 y}{\partial x^2} - S \frac{\partial^4 y}{\partial x^4} + L_T \frac{\partial^3 y}{\partial x^2 \partial t} - L_S \frac{\partial^5 y}{\partial x^4 \partial t} - L_V \frac{\partial y}{\partial t} + F(x, t)$$

in which:

F(x, t) denotes an external force at coordinate x on the string at time t;

M denotes mass per length;

S denotes stiffness of the string;

T denotes tension of the string;

Ls denotes a loss associated with the stiffness of the string;

Lt denotes a loss associated with the tension of the string; and

Lv denotes a loss associated with the turbulent flow of the fluid medium.

15. (Original) A method according to claim 14, wherein the approximation of the continuous wave equation is the discrete recursion formula:

$$y[n+1, j] = (y[n, j-2] \cdot c1 + y[n, j-1] \cdot c2 + y[n, j] \cdot c3 + y[n, j+1] \cdot c2 + y[n, j+2] \cdot c1 + y[n-1, j-2] \cdot c4 + y[n-1, j-1] \cdot c5 + y[n-1, j] \cdot c6 + y[n-1, j+1] \cdot c5 + y[n-1, j+2] \cdot c4) / M[j] + 2y[n, j] + F[n, j]/M[j]$$

in which:

dx = 1;

dt = 1;

y[n, j] denotes the excursion of discrete element j in the y-direction at time n;

y[n+1, j] denotes the excursion of discrete element j in the y-direction at time n+1;

$y[n, j+1]$ denotes the excursion of discrete element $j+1$ in the y -direction at time n ;
 $M[j]$ denotes the mass of discrete element j ;
 $F[n, j]$ denotes an additional external force acting on a discrete element j at time n ; and
 $c1$ to $c6$ are coefficients, which depend on the material parameters of the string and the surrounding media.

16. (Currently Amended) A method according to claim 15, wherein

$$c1 = -(S + Ls);$$

$$c2 = T + 4S + Lt + 4Ls;$$

$$c3 = -(2T + 6S + Lv + 2Lt + 6Ls);$$

$$c4 = Ls;$$

$$c5 = -(Lt + 4Ls); \text{ and}$$

$$c6 = Lv + 2Lt + 6Ls.$$

17. (Currently Amended) A method according to claim 15, wherein the discrete recursion formula is solved for the elements adjacent the respective supports by providing a dummy element at opposite ends of the string so that the excursion $y[n+1, -1]$ of a dummy element adjacent the movably supported element for the next sample is given by:

$$y[n+1, -1] = y[n+1, 0] - (y[n+1, 1] - y[n+1, 0])$$

and the excursion $y[n+1, x]$ of a dummy element adjacent the immovably supported element for the next sample is given by:

$$y[n+1, x] = -y[n+1, x-2].$$

18. (Cancelled)

19. (Currently Amended) A machine readable medium providing executable computer program instructions which when executed cause a data processing system to perform a method of simulating, in a machine, a string, the method comprising:

simulating a force acting on the string by a stream of a fluid medium flowing in a direction that has a component along a longitudinal axis of the string;

using forming a wave equation that relates movement of the string in time to the force acting on the string; and,

generating a sound based on the movement described in the wave equation~~wherein the force acting on the string simulates a stream of a fluid medium flowing relative to the string.~~

20. (Currently Amended) The machine readable medium ~~A method~~ according to claim 19, wherein:

the simulated string is supported between two supports and is aligned at rest in a first direction between the two supports;

a first of the two supports allows movement in a second direction orthogonal to the first direction and a second of the two supports does not allow movement; and

the string is caused from rest to vibrate in a plane, which includes the first and second directions, by turbulence in the fluid flow causing the stream of fluid medium to exert a pressure on the string in the second direction.

21. (Currently Amended) The machine readable medium ~~A method~~ according to claim 20, wherein:

movement of the string out of alignment with the first direction causes the stream of fluid medium flowing in the first direction to exert ~~a~~ the force on the string in the second direction.

22. (Currently Amended) The machine readable medium ~~A method~~ according to claim 19, wherein:

the simulated string is supported between two supports aligned in a first direction,

a first of the two supports is rigid and a second of the two supports allows movement in a second direction orthogonal to the first direction; and

the string is caused to vibrate in a plane, which includes the first and second directions, by the stream of fluid medium flowing in a direction having a component in the second direction.

23. (Currently Amended) The machine readable medium A-method according to claim 19, wherein:

the simulated string is supported between two supports aligned in an x-direction;

a first of the two supports allows movement in a y-direction orthogonal to the x-direction and a second of the two supports does not allow movement;

the string comprises a plurality of discrete elements aligned at rest in the x-direction and spaced apart by a distance dx; and

the discrete elements are able to move in discrete steps of time dt in the y-direction only.

24. (Currently Amended) The machine readable medium A-method according to claim 23, in which the string comprises a plurality of j discrete elements from j=0 at one end movably supported by the first support to j=x-1 at the opposite end immovably supported by the second support; wherein

j is an integer; and

the stream of fluid medium flows in the x-direction and exerts a pressure on the string between elements j=0 and j=1.

25. (Currently Amended) The machine readable medium A-method according to claim 24, wherein the force $F_{PRES}[n, 0]$ at time n acting on the immovably supported element j=0 due to the pressure on the string between the movably supported element j=0 and adjacent element j=1 is given by:

$$F_{PRES}[n, 0] = P * (y[n, 0] - y[n, 1]) / dx$$

in which:

P denotes the pressure exerted by the stream of fluid medium on the string between the movably supported element j=0 and adjacent element j=0;

y[n, 0] denotes the excursion of the movably supported element j=0 at time n; and

y[n, 1] denotes the excursion of the adjacent element j=1 at time n.

26. (Currently Amended) The machine readable medium A-method according to claim 24, wherein the force $F_{\text{TURB}}[n, 0]$ at time n acting on the immovably supported element $j=0$ due to the turbulence in the stream of fluid medium is given by:

$$F_{\text{TURB}}[n, 0] = C_{\text{TURB}} * N_{\text{RND}}[n]$$

in which:

C_{TURB} denotes a turbulence coefficient; and

$N_{\text{RND}}[n]$ denotes a random signal.

27. (Currently Amended) The machine readable medium A-method according to claim 24, wherein the excursion $y[n+1, 0]$ of the movably supported element for the next sample due to the pressure on the string between the movably supported element $j=0$ and adjacent element $j=1$ is given by:

$$y[n+1, 0] = y[n, 0] + (F_{\text{PRES}}[n, 0] + F_{\text{TURB}}[n, 0]) * dt^2 / M[0]$$

in which:

$y[n, 0]$ denotes the excursion of the movably supported element $j=0$ at time n ; and

$F_{\text{PRES}}[n, 0]$ denotes the force at time n acting on the movably supported element $j=0$ due to the pressure on the string between the movably supported element $j=0$ and adjacent element $j=1$;

$F_{\text{TURB}}[n, 0]$ denotes the force at time n acting on the movably supported element $j=0$ due to the turbulence in the stream of fluid medium; and

$M[0]$ denotes the mass of the movably supported element $j=0$.

28. (Currently Amended) The machine readable medium A-method according to claim 27, wherein the excursion $y[n+1, 0]$ is limited.

29. (Currently Amended) The machine readable medium A-method according to claim 24, wherein the stream of the fluid medium exerts a pressure on the string between each of the elements; and

wherein the force $F[n, j]$ at time n acting on each discrete element from $j=1$ to $j=x-2$ due to the pressure P is given by:

$$F[n, j] = P[j] * (y[n, j] - y[n, j-1]) / dx + P[j] * (y[n, j] - y[n, j+1]) / dx.$$

30. (Currently Amended) The machine readable medium A-method according to claim 29, wherein the pressure P decreases linearly or exponentially with increasing j .

31. (Currently Amended) The machine readable medium A-method according to claim 23, wherein the wave equation is an approximation of the continuous wave equation

$$M \frac{\partial^2 y}{\partial t^2} = T \frac{\partial^2 y}{\partial x^2} - S \frac{\partial^4 y}{\partial x^4} + L_r \frac{\partial^3 y}{\partial x^2 \partial t} - L_s \frac{\partial^5 y}{\partial x^4 \partial t} - L_v \frac{\partial y}{\partial t} + F(x, t)$$

in which:

$F(x, t)$ denotes an external force at coordinate x on the string at time t ;

M denotes mass per length;

S denotes stiffness of the string;

T denotes tension of the string;

L_s denotes a loss associated with the stiffness of the string;

L_t denotes a loss associated with the tension of the string; and

L_v denotes a loss associated with the turbulent flow of the fluid medium.

32. (Currently Amended) The machine readable medium A-method according to claim 31, wherein the approximation of the continuous wave equation is the discrete recursion formula:

$$y[n+1, j] = (y[n, j-2] \cdot c1 + y[n, j-1] \cdot c2 + y[n, j] \cdot c3 + y[n, j+1] \cdot c2 + y[n, j+2] \cdot c1 + y[n-1, j-2] \cdot c4 + y[n-1, j-1] \cdot c5 + y[n-1, j] \cdot c6 + y[n-1, j+1] \cdot c5 + y[n-1, j+2] \cdot c4) / M[j] + 2y[n, j] + F[n, j]/M[j]$$

in which:

$$dx = 1;$$

$$dt = 1;$$

$y[n, j]$ denotes the excursion of discrete element j in the y -direction at time n ;

$y[n+1, j]$ denotes the excursion of discrete element j in the y -direction at time $n+1$;

$y[n, j+1]$ denotes the excursion of discrete element $j+1$ in the y -direction at time n ;

$M[j]$ denotes the mass of discrete element j ;

$F[n, j]$ denotes an additional external force acting on a discrete element j at time n ; and

$c1$ to $c6$ are coefficients, which depend on the material parameters of the string and the surrounding media.

33. (Currently Amended) The machine readable medium A method according to claim 32, wherein

$$c1 = -(S + Ls);$$

$$c2 = T + 4S + Lt + 4Ls;$$

$$c3 = -(2T + 6S + Lv + 2Lt + 6Ls);$$

$$c4 = Ls;$$

$$c5 = -(Lt + 4Ls); \text{ and}$$

$$c6 = Lv + 2Lt + 6Ls.$$

34. (Currently Amended) The machine readable medium A method according to claim 32, wherein the discrete recursion formula is solved for the elements adjacent the respective supports by providing a dummy element at opposite ends of the string so that the excursion $y[n+1, -1]$ of a dummy element adjacent the movably supported element for the next sample is given by:

$$y[n+1, -1] = y[n+1, 0] - (y[n+1, 1] - y[n+1, 0])$$

and the excursion $y[n+1, x]$ of a dummy element adjacent the immovably supported element for the next sample is given by:

$$y[n+1, x] = -y[n+1, x-2].$$

35. (Cancelled)

36. (Currently Amended) An apparatus for simulating, in a machine, a string, the apparatus comprising:

a processing element to simulate a force acting on the string by a stream of a fluid medium flowing in a direction that has a component along a longitudinal axis of the string and using ~~form~~ a wave equation that relates movement of the string in time to the force acting on the string;

a sound generating element, coupled to the processing element, to generate a sound based on the movement described in the wave equation; and

a storage device, coupled to the processing element, to store data for simulating the string.
~~wherein the force acting on the string simulates a stream of a fluid medium flowing relative to the string, said apparatus comprising:~~

~~means for storing data for said simulating; and~~

~~means for simulating.~~

37. (Original) An apparatus according to claim 36, wherein:

the simulated string is supported between two supports and is aligned at rest in a first direction between the two supports;

a first of the two supports allows movement in a second direction orthogonal to the first direction and a second of the two supports does not allow movement; and

the string is caused from rest to vibrate in a plane, which includes the first and second directions, by turbulence in the fluid flow causing the stream of fluid medium to exert a pressure on the string in the second direction.

38. (Currently Amended) An apparatus according to claim 37, wherein:
movement of the string out of alignment with the first direction causes the stream of fluid medium flowing in the first direction to exert ~~a~~the force on the string in the second direction.
39. (Original) An apparatus according to claim 36, wherein:
the simulated string is supported between two supports aligned in a first direction,
a first of the two supports is rigid and a second of the two supports allows movement in a second direction orthogonal to the first direction; and
the string is caused to vibrate in a plane, which includes the first and second directions, by the stream of fluid medium flowing in a direction having a component in the second direction.
40. (Original) An apparatus according to claim 36, wherein:
the simulated string is supported between two supports aligned in an x-direction;
a first of the two supports allows movement in a y-direction orthogonal to the x-direction and a second of the two supports does not allow movement;
the string comprises a plurality of discrete elements aligned at rest in the x-direction and spaced apart by a distance dx ; and
the discrete elements are able to move in discrete steps of time dt in the y-direction only.
41. (Original) An apparatus according to claim 40, in which the string comprises a plurality of j discrete elements from $j=0$ at one end movably supported by the first support to $j=x-1$ at the opposite end immovably supported by the second support; wherein
 j is an integer; and
the stream of fluid medium flows in the x-direction and exerts a pressure on the string between elements $j=0$ and $j=1$.
42. (Original) An apparatus according to claim 41, wherein the force $F_{\text{PRES}}[n, 0]$ at time n acting on the immovably supported element $j=0$ due to the pressure on the string between the movably supported element $j=0$ and adjacent element $j=1$ is given by:

$$F_{\text{PRES}}[n, 0] = P * (y[n, 0] - y[n, 1]) / dx$$

in which:

P denotes the pressure exerted by the stream of fluid medium on the string between the movably supported element $j=0$ and adjacent element $j=1$;

$y[n, 0]$ denotes the excursion of the movably supported element $j=0$ at time n ; and

$y[n, 1]$ denotes the excursion of the adjacent element $j=1$ at time n .

43. (Original) An apparatus according to claim 41, wherein the force $F_{\text{TURB}}[n, 0]$ at time n acting on the immovably supported element $j=0$ due to the turbulence in the stream of fluid medium is given by:

$$F_{\text{TURB}}[n, 0] = C_{\text{TURB}} * N_{\text{RND}}[n]$$

in which:

C_{TURB} denotes a turbulence coefficient; and

$N_{\text{RND}}[n]$ denotes a random signal.

44. (Cancelled).

45. (Original) An apparatus according to claim 41, wherein the excursion $y[n+1, 0]$ of the movably supported element for the next sample due to the pressure on the string between the movably supported element $j=0$ and adjacent element $j=1$ is given by:

$$y[n+1, 0] = y[n, 0] + (F_{\text{PRES}}[n, 0] + F_{\text{TURB}}[n, 0]) * dt^2 / M[0]$$

in which:

$y[n, 0]$ denotes the excursion of the movably supported element $j=0$ at time n ; and

$F_{\text{PRES}}[n, 0]$ denotes the force at time n acting on the movably supported element $j=0$ due to the pressure on the string between the movably supported element $j=0$ and adjacent element $j=1$;

$F_{\text{TURB}}[n, 0]$ denotes the force at time n acting on the movably supported element $j=0$ due to the turbulence in the stream of fluid medium; and

$M[0]$ denotes the mass of the movably supported element $j=0$.